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NATIONAL DAM INSPECTION PROGRAM. HILLOCH DAM, NDI NUMBER PA-009--ETC(U)
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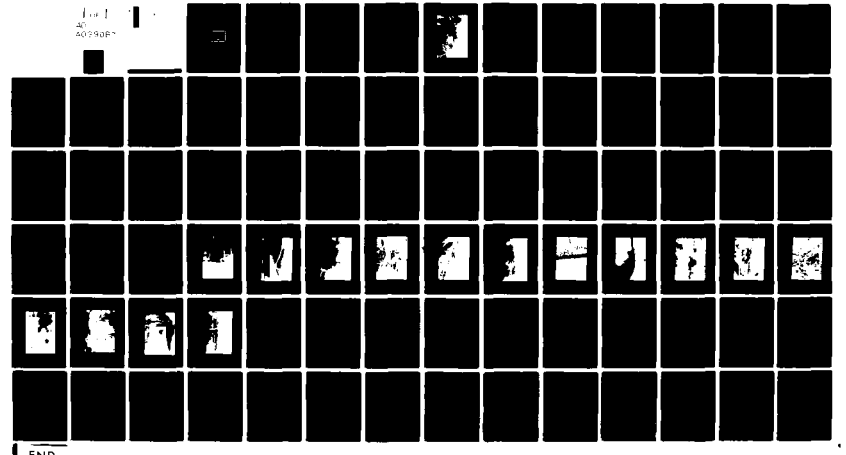

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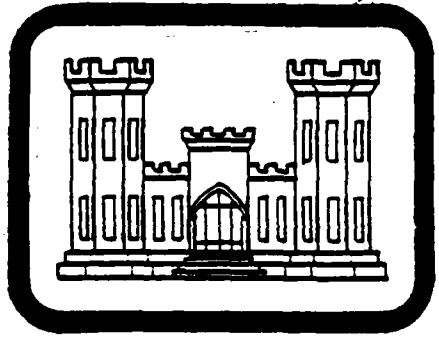
DELAWARE RIVER BASIN

TRIBUTARY TO HARVEY RUN

HILLOCH DAM
DELAWARE COUNTY, PENNSYLVANIA

NDI NO. PA 00933
DER NO. 23-89

PHASE I INSPECTION PROGRAM
NATIONAL DAM INSPECTION PROGRAM.



Prepared by:

WOODWARD-CLYDE CONSULTANTS
5120 Butler Pike
Plymouth Meeting, Pennsylvania 19462

Submitted to:

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

March 1981

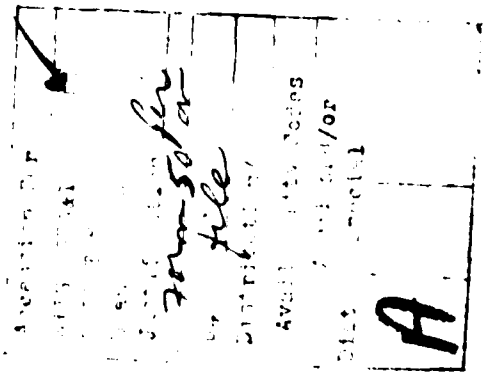
PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to expeditiously identify those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the size and hazard classifications. The selected spillway design flood can range from the 100 Year Flood to the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff). The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	Hilloch Dam
County Located:	Delaware County
State Located:	Pennsylvania
Stream:	Tributary to Harvey's Run
Coordinates:	Latitude 39° 52.2'
	Longitude 75° 34.0'
Date of Inspection:	November 19, 1980

Hilloch Dam is a privately owned dam used for recreational purposes. The dam is in fair condition and the spillway is considered to be in poor condition.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Small" size dam and "Significant" hazard classification is the 100 Year Event to one-half the Probable Maximum Flood (PMF). Based on the small capacity of the reservoir and limited downstream development the 100 Year Event has been selected as the spillway design flood.

Hydrologic and hydraulic computations presented in Appendix D indicate the spillway structure is capable of discharging the 100 Year Event without overtopping the embankment. The spillway is therefore considered "Adequate" although available freeboard during the spillway design storm is limited to 0.3 feet under existing conditions.

It is recommended that the following measures be undertaken immediately. All items should be performed under the supervision of a registered professional engineer experienced in the design and construction of dams.

(1) The trees should be removed by a method determined not to increase the potential hazard of dam failure by piping through root channels.

(2) The spillway and discharge channel should be rehabilitated to prevent spillway discharge from flowing against the toe of the embankment.

(3) Seepage through the dam should be monitored for the development of turbidity and an increase in quantity.

(4) The blow-off pipe through the embankment should be fitted at the upstream end with an operational control device.

(5) A large crack in the spillway wall should be sealed to prevent further deterioration. If movement of the wall has not stabilized then it should be replaced.

Because of the potential for property damage in the event of failure, a formal procedure of observation and warning during periods of high precipitation should be developed and implemented for this facility. This procedure should be coordinated with local authorities and should include a method of warning downstream residents that high flows are expected. In addition, an operational and maintenance procedure should be developed to insure that all pertinent items are carefully inspected on a regular basis and maintained in the best possible condition.

Mary F. Beck — 3/19/81

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Date

APPROVED BY:

James Peck — 2 APR 81

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date

OVERVIEW
HILLOCH DAM, DELAWARE COUNTY, PENNSYLVANIA

TABLE OF CONTENTS

PHASE 1 INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
HILLOCH DAM
NATIONAL ID NO. PA. 00933
DER NO. 23-89

SECTION 1
PROJECT INFORMATION

1.1 General.

A. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Hilloch Dam is an earth embankment about 20.1 feet high and 345 feet long impounding a 55 acre feet reservoir within a 0.4 square mile watershed. The homogeneous embankment was constructed over a 15-foot wide cutoff trench located under the dam centerline. Specifications required fill materials to contain 20 to 35 percent clay and the upstream embankment slope to be treated with bentonite and protected with hand placed ripap. The crest width varies from 11 to 14 feet, the upstream embankment slope above water level is irregularly scooped and the downstream embankment slope averages approximately 2.5H:1V. The minimum crest elevation is 229.9 and the normal reservoir elevation is about 228.0. The dam crest is protected by grass while brush and small trees are growing at the upstream waterline. Small to moderate size trees, underbrush and grass are growing on the downstream embankment slope. Plan and cross-section views of the dam are shown on Plates 2 and 3, Appendix E.

The spillway at the left end of the dam is a paved channel about 36 feet wide, with a low concrete, brick and stone sill along the dam axis. The right spillway wall is reinforced concrete while the left side of the channel is the existing hillside. The spillway discharges into an unlined channel excavated into the hillside which carries the water to the toe of the dam. A 5-inch diameter steel, pond-drain pipe is located near the right abutment. The downstream invert is at elevation 209.9. Apparently, no upstream control device exists and the upstream end of pipe is plugged. It is unknown if the plug is removable.

b. Location. The dam was constructed across an unnamed tributary to Harvey Run approximately 1,750 feet upstream from the confluence of the tributary with Harvey Run. The site is about one mile southwest of the intersection of U.S. Routes 1 and 202 in Birmingham Township, Delaware County, Pennsylvania. The dam and reservoir are located on USGS Quadrangle map entitled "Wilmington North, Delaware, Pennsylvania" at coordinates N39° 52.2', W75° 34.0'. A Regional Location Plan of Hilloch Dam is included as Plate 1, Appendix E.

c. Size Classification. The dam is classified as a "Small" size dam by virtue of its less than 40-foot height and less than 1000 acre-feet storage capacity to the top of the dam.

d. Hazard Classification. A "Significant" hazard classification is assigned consistent with the dam's location above residential and commerical properties and the potential for property damage with few or no lives lost within the nearby downstream area.

e. Ownership. Hilloch Dam is owned by Mr. William P. Stevenson and Mr. William Paulsen. All correspondence should be addressed to Mr. Stevenson, R. D. #2, Box 56, Heyburn Road, Chadds Ford, Pennsylvania 19317 and Mr. Paulsen at R.D. 2, Box 54BB, Heyburn Road, Chadds Ford, Pennsylvania 19317..

f. Purpose of Dam. The purpose of this dam is private recreational usage.

g. Design and Construction History. The dam was designed by James F. Pierce, Architect, for Mr. William H. Porter, a former property owner. The permit application and related correspondence in 1949 describe the dam as an earth dike having a volume about 7,000 cubic yards being 16.5 feet high, and with two stone and concrete spillways. Subsequently, a revised plan, with a single spillway was submitted and reviewed by the Department of Forests and Waters. As a result of this review, substantial design and construction modifications were recommended consistent with conventional engineering practice. Included among these was a required minimum spillway capacity of 1,000 cfs. On December 13, 1949, a permit was issued to build a dam having a 52-foot wide spillway with an upstream cutoff wall and anti-seep fins extending 10 feet into the embankment and left abutment.

In May 1950, the dam construction was visited by a state engineer who noted numerous construction deficiencies; the most important of which was the absence of a spillway. Also noted were the possibility of inadequate stripping prior to the embankment construction and the failure to encase the blow-off pipe, a second hand "boiler tube", in concrete. Substandard construction practices continued through the summer. Subsequently, it was resolved that the upstream and downstream slopes should be constructed to

their design slopes of 3H:1V and 2H:1V respectively. The upstream 20 feet of the blow-off pipe was to be exposed, encased in concrete, and provided with at least two anti-seep collars and a control mechanism.

The spillway excavation was examined October 1950 and exposed rock at the left side of the spillway noted. A January 1951, state memorandum concurred with some changes in the spillway design consistent with the rock exposure. The left spillway wall was eliminated as were the upstream cutoff wall and the paving upstream of the weir. Notes on the final revised plan, March 1951, eliminated all cutoff walls and anti-seep fins. During an April 1951 meeting at the site, slight seepage was noted at the downstream toe of the dam approximately 50 feet to the right of the spillway. It was also recommended that the spillway channel be cut deeper to reduce the potential for erosion of the downstream embankment slope.

Late in 1951, the dam was completed and a hairline crack was observed in the right spillway abutment. An inspection of the dam in early 1952 disclosed evidence of settlement of the dam crest adjacent to the right spillway wall and the spillway channel was not cleared downstream of the paving. The spillway abutment wall was not long enough to prevent spillway discharge from flowing along the downstream toe.

There are no further records related to the history of the dam until 1973 when a real estate subdivision was proposed. About that time, the spillway was evaluated by the Department of Environmental Resources and estimated to have a capacity of 780 cfs.

h. Normal Operating Procedures. Reservoir outflow is controlled by the spillway at the left end of the dam. All flows discharge over the spillway crest at about elevation 227.8.

1.3 Pertinent Data.

A summary of pertinent data for Hilloch Dam is presented as follows.

a. Drainage Area (square miles)	0.4
b. Discharge at Dam Site (cfs)	
Maximum Known Flood	Unknown
At minimum Embankment Crest	611

c.	Elevation (feet above MSL) [1]	
	Top of dam (design, estimated)	230.7
	Top of dam (existing)	229.9
	Spillway Crest (Centerline)	227.8
	Pond Drain Inlet	Unknown
	Pond Drain Outlet	209.8
	Minimum Downstream Toe	209.8
d.	Reservoir (feet)	
	Length at Normal Pool	800
	Length at Maximum Pool (est)	850
e.	Storage (acre-feet)	
	To Normal Pool	39
	To Top of Dam	55
f.	Reservoir Surface (acres)	
	Normal Pool	7.4
g.	Dam Data	
	Type	Earth fill
	Length	345 feet
	Maximum height	20.1 feet
	Top Width	11 to 14 feet
	Volume	5300 cu. yd.
	Side slopes	
	Upstream design	3H:1V
	Upstream (existing, above waterline)	varies
	Downstream (design)	2H:1V
	Downstream (existing)	2.5H:1V
	Cutoff	Trench beneath dam centerline
	Grout Curtain	None
h.	Spillway	
	Type	Channel with low sill at entrance
	Elevation (minimum)	227.8 feet
	Width (bottom)	About 36 feet
	Length	About 50 feet
i.	Pond Drain	
	Type	5-inch used steel "boiler tube"
	Length	Unknown
	Inlet invert elevation	Unknown
	Outlet invert elevation	209.9

(1) All elevations are relative to reservoir level, assumed to be elevation 228.0 at time of inspection.

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Data Available. A summary of the available engineering data on Hilloch Dam is attached as Appendix B. Engineering data available for review are contained in the Department of Environmental Resources (DER) files. These data include applications, memos, reports, letters and design drawings. Additional information was obtained from conversations with Mr. and Mrs. Stevenson and Mr. Lundquist, a nearby resident.

b. Design Features. The principal design features of Hilloch Dam are illustrated on the plans and profile enclosed in Appendix E as Plates 2 and 3. A detailed description of the design features is presented in Section 1.2, paragraph a, and pertinent data relative to the structure are presented in Section 1.3.

2.2 Construction.

The known construction history of Hilloch Dam is presented in Section 1.2, paragraph g.

2.3 Operational Data.

There are no operational records maintained by the Owners. There are no minimum flow requirements for the downstream channel. No water level measurements or rainfall records are maintained within the watershed.

2.4 Evaluation.

a. Availability. All engineering data evaluated and reproduced for this report were provided by DER and supplemented by conversations with the Owner.

b. Adequacy. Data included in state files are not sufficient to evaluate the engineering aspects of this dam.

c. Validity. There is no reason to question the validity of the limited available data.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. Observations and comments of the field inspection team are contained in the checklist enclosed herein as Appendix A, and are summarized and evaluated as follows. In general, the embankment is considered to be in fair condition, and the spillway and outlet works to be in poor condition.

b. Dam. The vertical alignment of the dam was checked, and the profile is shown on Sheet 5B, Appendix A. Although the profile is uneven there are no distortions in alignment or grade that would be indicative of deep-seated movement of the embankment or foundation. The minimum crest elevation is 229.9, representing about 0.8-foot settlement adjacent to the spillway wall. The upstream embankment slope above the waterline has a low freeboard and is covered with brush and small trees, Photograph 6. No meaningful measurement of the upstream slope could be made. The design riprap on the upstream embankment could not be seen and the embankment is benched at the waterline. Slight erosion was noted adjacent to the spillway wall.

The crest of the dam ranges from 11 to 14 feet wide and is protected with grass. The downstream embankment slope, measured 2.5H:1V, or flatter, appears to have been planted with pine trees, now up to 14 inches in diameter. The density of the trees has prevented grass from growing under the trees, however, the forest litter and pine needles have protected the embankment from erosion and foot traffic damage. The downstream junction of the embankment and right abutment is in good condition. Some erosion is occurring at the left end of the embankment as a result of spillway discharge. Apparently the spillway discharge channel was not deepened as recommended, (see Paragraph 1.2, g) to prevent spillway discharge from flowing against the toe of the embankment. The ground is soft with water just under the surface in the area 70 to 100 feet to the right of the spillway, see Sheet 5A, Appendix A. Part of the water could be spillway discharge exiting the ground surface. The ditch downstream of the outlet pipe contains standing water and areas on the right abutment were soft and wet. A rather extensive marshy area was observed downstream from the right abutment of the dam. About 70 to 100 feet downstream of the dam, water was flowing underground and entering the small stream shown on Photograph 12.

c. Appurtenant Structures.

1. Spillway. Although final revised plans show a 52-foot wide spillway, the actual constructed width is 36 feet. The spillway approach channel is under water and part of the upstream

right spillway wall has broken off. The spillway entrance is defined by a 36-foot long, one-foot wide, 2-inch high concrete sill that, in places, consists of stone and bricks, Photograph 2. Trees and brush are growing through the paving retarding spillway discharge, Photograph 1. Voids were detected at several locations beneath the paving. Normal spillway discharge flows along the left abutment downstream of the paving while large discharges appear to flow adjacent to the embankment causing erosion, Photograph 10.

There is a vertical crack in the right spillway wall at about the axis of the dam. This crack was first observed shortly after the completion of the construction of the dam. At that time, the crack was described as being a "hairline feature into which a pin could barely be inserted". By the November 1980 inspection, the crack was about one-inch wide and a ruler could be inserted 14 inches into the crack.

2. Outlet Works. A five-inch diameter steel pipe exits the downstream face of the dam at elevation 209.9. The ditch downstream of the pipe contained standing water but no water was observed flowing from this pipe. There are no valves or other control devices in evidence, or reported to exist, to drain the reservoir. The pipe was reported sealed at the upstream end after the construction of the dam.

d. Reservoir. At the time of the inspection, the water in the reservoir was at elevation 228.0, the approximate elevation of the spillway crest. The reservoir side slopes are moderate and vegetated to the waterline with grass. No large debris was observed around the reservoir. Consistent with a reported maximum depth in the reservoir of about six feet at normal pool level, it is probable that substantial sedimentation has occurred.

e. Downstream Channel. The downstream channel meanders through a marshy, lightly wooded and brush covered flood plain. Immediately downstream from the dam the channel gradient is about 0.028 and further downstream flattens to about 0.008. About 390 feet downstream from the dam, the spillway discharge joins with another small stream and the combined flow passes through five 30-inch diameter, reinforced-concrete pipe culverts beneath a private road located approximately 600 feet downstream from the dam. Approximately 50 feet further downstream, the stream flows through a culvert 10 feet wide and 8.5 feet high beneath a railway embankment approximately 55 feet high.

Flood flows are expected to pond upstream from the railroad culvert. In the event of a dam failure, water is expected to flow through Heyburn Road underpass beneath the railroad embankment. The roadway underpass is approximately 14.8 feet above the stream channel. Such a large flow might enter the house downstream of the railroad embankment and, possibly, a commercial establishment

approximately 1,500 feet downstream from the railroad embankment. Therefore, a "Significant" hazard potential classification for this structure is indicated.

3.2 Evaluation.

Inspection of the dam and appurtenant facilities indicates little or no routine maintenance has been provided to the structure, allowing considerable deterioration of the spillway channel. The spillway is in poor condition requiring sealing of the large crack in the spillway wall. If movement of the wall has not stopped, that portion of the wall may need replacing. The spillway channel requires removal of all trees and brush and renovation of the channel to prevent spillway flow from entering the ground. High spillway flows must be deflected from the embankment toe. The outlet pipe should be fitted with an operational control device at its upstream end. Trees and brush should be removed from the waterline and the embankment protected from further wave damage. Large trees present a danger to earth embankments because of the possibility of blowing over and creating holes in the embankment, and rotting root systems which may allow a piping condition (soil washing out of the embankment) to exist. The large trees indicate an extensive root system within the embankment. Therefore, the trees should not be removed without considering the long-term effects on the stability of the embankment.

Seepage is not assessed to represent a serious condition at this time. The seepage should be monitored for development of turbidity or increase in volume. In summary, the dam is considered to be in fair condition and the spillway and outlet works are considered to be in poor condition.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures.

Operation procedures are discussed in Section 1.2. Operation of the dam does not require a dam tender. All flow discharges through the spillway. There are no written operation or maintenance procedures for this structure.

4.2 Maintenance of Dam.

The dam is maintained by the Hilloch Homeowner's Association comprised of the landowners bordering the reservoir. Maintenance is limited to mowing the grass on the dam crest and removing any debris.

4.3 Maintenance of Operating Facilities.

There are no operational facilities to be maintained.

4.4 Warning System in Effect.

There are no written warning procedures to be followed in the event of high precipitation. It is understood that in the event dangerous conditions are observed at the dam, warnings would be given through the local fire department.

4.5 Evaluation.

It is judged that the current operating procedure, which does not require a dam tender, is a realistic means of operating Hilloch Dam. There are no written operational, maintenance or warning procedures. Maintenance and operational procedures should be developed, including a checklist of items to be observed, operated and inspected, and maintained on a regular basis.

Since a formal warning procedure does not exist, one should be developed and implemented during periods of extreme rainfall. Procedures should consist of a method of notifying residents and businesses downstream if potentially high flows are imminent or if dangerous conditions are developing.

SECTION 5
HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features

a. Design/Evaluation Data. Original data is limited to the state's requirement that the spillway be designed to pass not less than 1,000 cfs. The state indicated that a 52-foot wide spillway 3.5 feet deep would be required to discharge 1,000 cfs. The recommendation was incorporated into the final design of the dam but not constructed. Hydrologic and hydraulic evaluations made as a part of this investigation are contained in Appendix D.

The watershed is about 0.85 miles long and about 0.47 miles wide, having a total area of 0.4 square miles. Elevations range from a high of 420 in the upper reaches to 228 at normal pool elevation. The steep watershed is about 25 percent wooded. Less than 10 percent of the area of the watershed contains residential development. Residential development can be expected to continue throughout the watershed.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Small" size dam and "Significant" hazard potential classification is the 100 Year Event to 50 percent of the Probable Maximum Flood. Because of the small total capacity of the reservoir and limited downstream development, the selected spillway design flood is the 100 Year Event.

b. Experience Data. No reservoir level records are maintained. The reservoir level was reported not to vary more than about one to one and a half inches above normal pool level.

c. Visual Observations. Observed conditions that indicate a possible reduction in spillway capacity during the spillway design flood are the embankment settlement adjacent to the right spillway wall and the extensive brush and tree growth in the spillway channel, see Photograph 10. Other observations regarding the condition of the downstream channel spillway and reservoir are presented in Appendix A and are discussed in greater detail in Section 3.

d. Overtopping Potential. The overtopping potential of this dam was estimated using the HEC-1, Dam Safety Version, computer program. A brief description of the program is included in Appendix D. Calculations indicate that the maximum spillway capacity is about 611 cfs when the reservoir level is at the minimum embankment crest elevation. The HEC-1, computed 100 year peak inflow is 516 cfs. The spillway would discharge the 100 year event with about 0.3 feet of freeboard under existing conditions. If the embankment crest was raised to the design elevation and the spillway channel

cleared of brush and trees, the spillway would be capable of discharging the 100 year event with 1.2 feet of freeboard, as shown in Appendix D.

e. Spillway Adequacy. As the spillway will discharge the 100 year event without overtopping the embankment, the spillway classification is considered "Adequate". Current state regulations require that sufficient freeboard be provided to prevent overtopping of the dam during the spillway design flood and to allow for wave and ice action. For this small reservoir a minimum value of one-foot freeboard should be provided.

f. Downstream Conditions. About 390 feet downstream of the dam, the spillway discharge joins with a small stream draining the downstream 0.8 square mile watershed. See Plate 1, Appendix E. The combined discharge flows north under an abandoned railroad embankment. The minimum elevation of the railroad embankment crest is about 260 feet. The combined discharge flows through a culvert 10 feet wide and about 8.5 feet high. A 22-foot wide underpass conveys Heyburn Road through the railroad embankment. The highway underpass invert is about 14.8 feet above the stream culvert invert. Downstream of the railroad embankment is the first house that would be subject to flood damage in the event of failure of Hilloch Dam. Measurements taken from a contour map located in the state files indicate that the area immediately downstream of the dam is capable of storing approximately 44 acre-feet before water would flow through the highway underpass. It was estimated that, a rapid failure of the dam during the spillway design flood, combined with the discharge from the 0.8 square mile drainage area downstream of the dam, would cause water to flow through the highway underpass and flood the home downstream of the railroad embankment. As loss of life was not envisioned as a result of failure of this dam, a "Significant" hazard potential classification is indicated.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. Visual observations detected no evidence of potential instability of the dam. The downstream slope is uniform with no signs of significant erosion or sloughing. Some slight erosion was noted adjacent to the spillway channel as well as some wave erosion on the upstream face. The crest of the dam is protected by a well maintained growth of grass.

The spillway is judged to be in poor condition as a result of the cracked pavement and trees and brush growth. The voids detected beneath the paving are indicative of some erosional process, however, there does not appear to be any current threat to the stability of the spillway. Some water noted just under the ground surface to the right of the spillway may be attributed to spillway discharge, exiting the ground at that point. As no evidence of migration of fines through the embankment was noted, that and other seepage noted in Section 3 is assessed not to be a serious problem at this time.

b. Design and Construction Data. All available documents, drawings and data from the Department of Environmental Resources, and supplemented by conversations with the Owner were assessed and reviewed. These documents contain no stability analysis of the embankment. Based upon the lack of visual signs of significant deterioration and the geometric configuration of the embankment, it is qualitatively assessed that the stability of the embankment is adequate.

Detrimental to the long-term stability of earthern embankments is the presence of extensive root systems within the embankments. The closely spaced pine trees have trunk diameters up to 14 inches; thus, it is considered probable that the root systems are fairly extensive. The long-term stability of the embankment could be adversely affected when these trees die and roots rot, forming channels for water to percolate through the dam. If these trees are blown over, large craters could be formed, possibly leading to a breach of the dam.

c. Operating Records. There are no operational or maintenance records maintained for this dam.

d. Post-Construction Changes. There is no record nor is there any evidence that any major modifications were made to the dam since construction.

e. Seismic Stability. The dam is located in Seismic Zone 1. Normally it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake conditions. As the dam is qualitatively assessed to be stable under static loading conditions, it can be reasonably assumed to be safe under seismic loading conditions.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Evaluation. Visual inspection indicates that the embankment of Hilloch Dam is in fair condition and the spillway and outlet structures are in poor condition.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Small" size dam and "Significant" hazard classification is the 100 Year Event to one-half the Probable Maximum Flood. Based on the small capacity of the reservoir and limited downstream development, the 100 Year Event has been selected as the spillway design flood.

Hydrologic and Hydraulic computations presented in Appendix D indicate the spillway structure is capable of discharging the 100 Year Event without overtopping the embankment. The spillway is therefore considered "Adequate", although, the available freeboard during the spillway design storm is limited to 0.3 feet under existing conditions.

b. Adequacy of Information. The combined visual inspection and simplified calculations presented in Appendix D were sufficient to indicate that the need for further investigations is limited to those required for rehabilitation of the existing structure.

c. Urgency. It is recommended that the measures presented in Section 7.2 be implemented as specified.

7.2 Remedial Measures.

a. Facilities. All items should be performed under the supervision of a registered professional engineer experienced in the design and construction of dams.

(1) The trees should be removed by a method determined not to increase the potential hazard of dam failure by piping through root channels.

(2) The spillway and discharge channel should be rehabilitated to prevent spillway discharge from flowing against the toe of the embankment.

(3) Seepage through the dam should be monitored for the development of turbidity and an increase in quantity.

(4) The blow-off pipe through the embankment should be fitted at the upstream end with an operational control device.

(5) The large crack in the spillway wall should be sealed to prevent further deterioration. If movement of the wall has not stabilized, then it should be replaced.

b. Operation and Maintenance Procedures. Because of the potential for property damage in the event of a failure, a formal procedure of observation and warning during periods of high precipitation should be developed and implemented for this facility. This procedure should be coordinated with local authorities and should include a method of warning downstream residents that high flows are expected. In addition, an operation and maintenance procedure should also be developed to insure that all pertinent items are carefully inspected on a regular basis and maintained in the best possible condition.

APPENDIX

A

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam *Hilloch Dam*

County *Delaware* State *Pennsylvania*

NDI# *PA 00933* DER# *23-89* Type of Dam *Earth*

Hazard Category *Significant*

Date(s) Inspection *Nov. 19, 1980*

Weather *Sunny* Temperature *40's*

Pool Elevation at Time of Inspection *228±* M.S.L.

Tailwater at Time of Inspection *NA* M.S.L.

Inspection Personnel:

Mary F. Beck (Hydrologist)	*Vincent McKeever (Hydrologist)*
Raymond S. Lambert (Geologist)	*John H. Frederick, Jr. Principal (2/10/81)*
Richard E. Mabry (Geotechnical)	

Mary F. Beck Recorder

Remarks:

Mr. and Mrs. William Stevenson and Mr. Bruce Lundquist were on site and provided assistance to the inspection team.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	N/A	
STRUCTURE TO ABUTMENT/ EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

CONCRETE/MASONRY DAMS

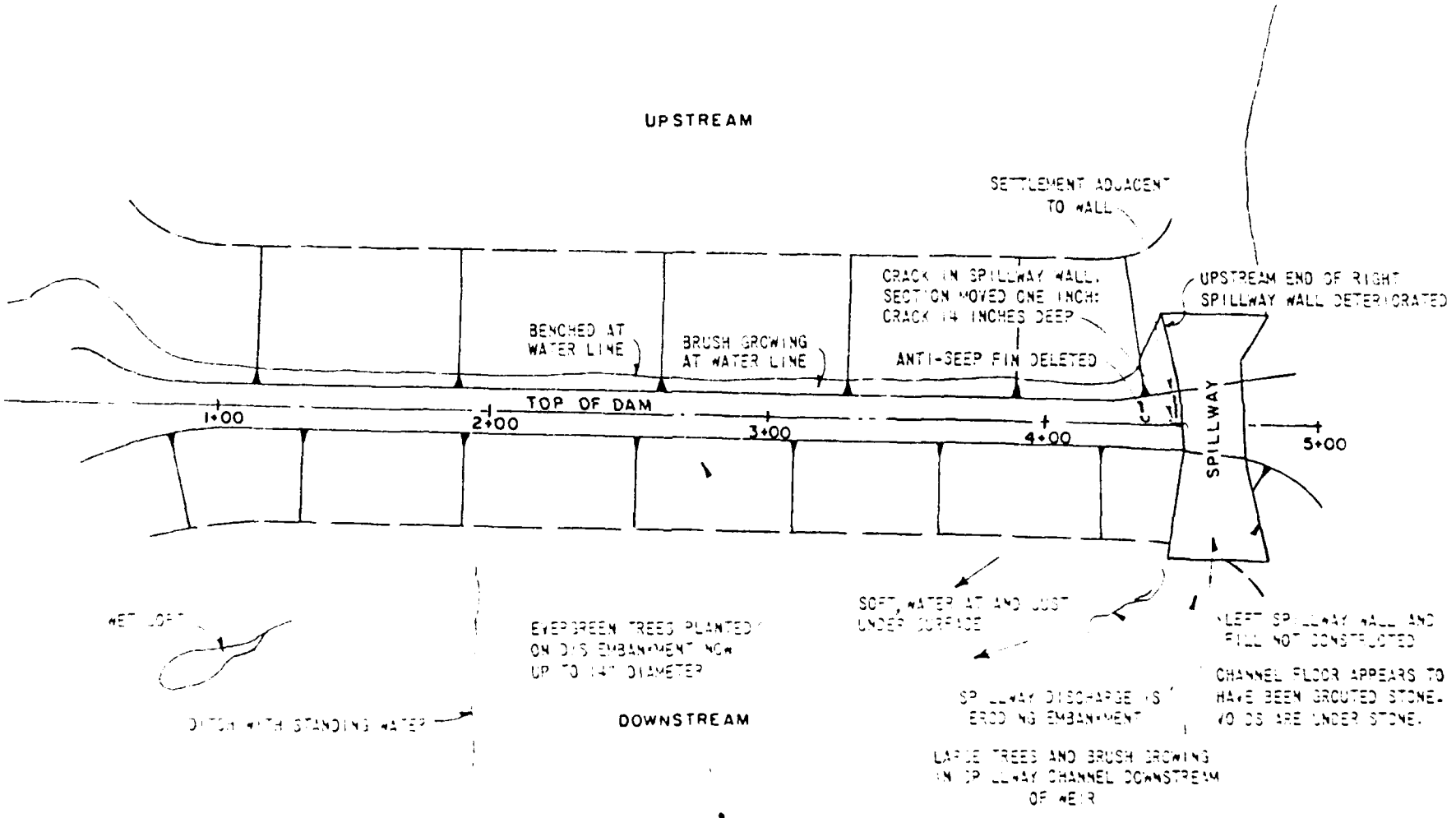
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	*None observed*	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	*None observed*	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	*None observed except by spillway discharge, see text, Section 3.*	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	*Vertical alignment is shown on Sheet 5B, Appendix A*	
RIPRAP FAILURES	*Upstream embankment above waterline not protected with riprap*	

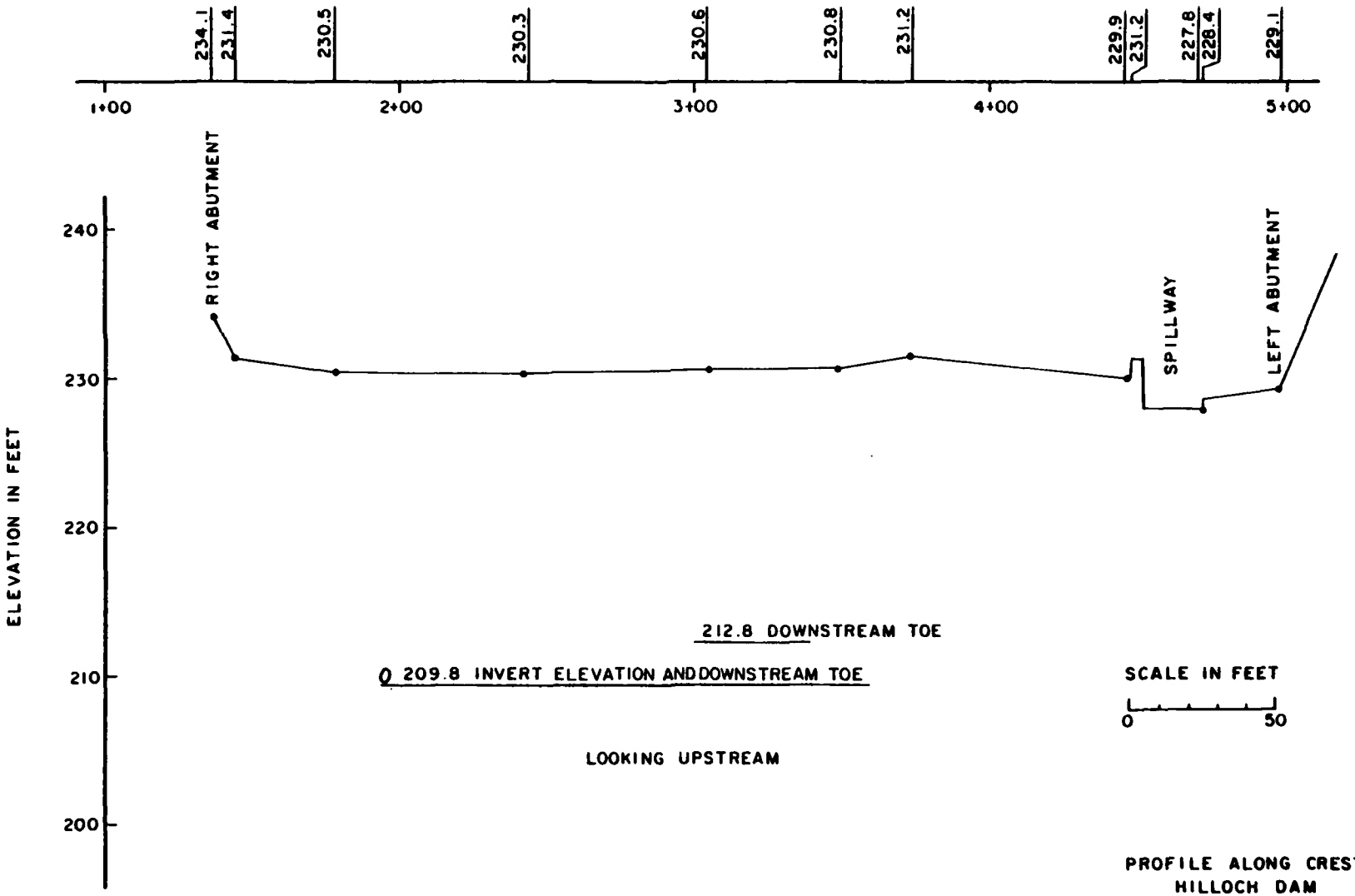
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
Vegetation	*The crest is protected by grass. Brush and small trees are growing at water line and embankment is benched. Pine trees, presently up to 14 inches in diameter, are on downstream embankment.*	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	*Up- and downstream junctions of embankment and right abutment are in good condition. Upstream junction of spillway and embankment has some erosion. Spillway flow is eroding part of the embankment.*	
ANY NOTICE-ABLE SEEPAGE	*Yes, see Sheet 5A of 11*	
STAFF GAGE AND RECORDER	*None*	
DRAINS	*None located*	



FIELD OBSERVATION PLAN
HILLOCH DAM

SHEET 5A OF 11



PROFILE ALONG CREST
HILLOCH DAM

SHEET 5B OF 11

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	*N/A*	*5-inch steel pipe through embankment*
INTAKE STRUCTURE	*None*	
OUTLET STRUCTURE	*None*	
OUTLET CHANNEL	*Small ditch conveying leakage, seepage to stream.*	
EMERGENCY GATE	*None, pipe sealed at upstream end.*	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	*A low concrete and block sill is across spillway channel entrance.*	
APPROACH CHANNEL	*Channel not visible under water, design drawings indicate an underwater channel*	
DISCHARGE CHANNEL	*Channel downstream of weir has trees and brush growing through the paving. Voids under paving. High flows in channel are eroding the embankment.*	
BRIDGE AND PIERS	*None*	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
TYPE	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/ SURVEYS	*None*	
OBSERVATION WELLS	*None*	
WEIRS	*None*	
PIEZOMETERS	*None*	
OTHER	*None*	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS REMARKS OR RECOMMENDATIONS
SLOPES	*Reservoir side slopes are moderate and vegetated to water line with grass. No large debris was noted.*
SEDIMENTATION	*Sedimentation was reported, the reservoir is reported as shallow, about 6 feet except immediately upstream of the dam*
WATERSHED	*About 25% wooded with predominantly steep watershed slopes.*

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	*The downstream channel flows about 500 feet through a lightly wooded and brush covered flood plain to a culvert 10 feet wide and 8 feet high under a 55 foot high railroad embankment. About 40 feet upstream of the culvert is a private road with 5-30" RCP culverts under it.*
SLOPES	*The valley gradient immediately downstream of the dam is about 0.028, and about 0.008 further downstream.*
APPROXIMATE NO. OF HOMES AND POPULATION	*About 380 feet downstream of the dam, spillway discharge joins with a small stream, 250 feet further downstream the combined flow passes through a 10-foot wide, 8-foot high culvert under a 55-foot high railroad embankment. Normally, flood flows pond upstream of the culvert. In the event of a dam failure, flow is expected in the roadway underpass (about 14.8 feet above the channel invert). Breach flow would be expected to enter the house downstream of the railroad embankment. Breach flow could also increase damage at the site 1500 feet downstream of the embankment.*

APPENDIX

B

HILLOCH DAM
CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Hilloch Dam

NDI NO. PA. 00933 DER NO. 23-89

ITEM	REMARKS
AS-BUILT DRAWINGS	None available
REGIONAL VICINITY MAP	See Plate 1, Appendix E
CONSTRUCTION HISTORY	See text, Section 1.2
TYPICAL SECTIONS OF DAM	See Appendix E
OUTLETS - PLAN	
DETAILS	See Appendix E and text, Section 3
CONSTRAINTS	
DISCHARGE RATINGS	See Appendix D

ITEM	REMARKS
RAINFALL/ RESERVOIR RECORDS	None available
DESIGN REPORTS	None
GEOLOGY REPORTS	See Appendix F
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	No original computations
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None known
POST CONSTRUCTION SURVEYS OF DAM	None known

ITEM	REMARKS
BORROW SOURCES	Reservoir Area
MONITORING SYSTEMS	None
MODIFICATIONS	None known
HIGH POOL RECORDS	None known
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	None

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	
DETAILS	No as-built drawings available
OPERATING EQUIPMENT PLANS AND DETAILS	None

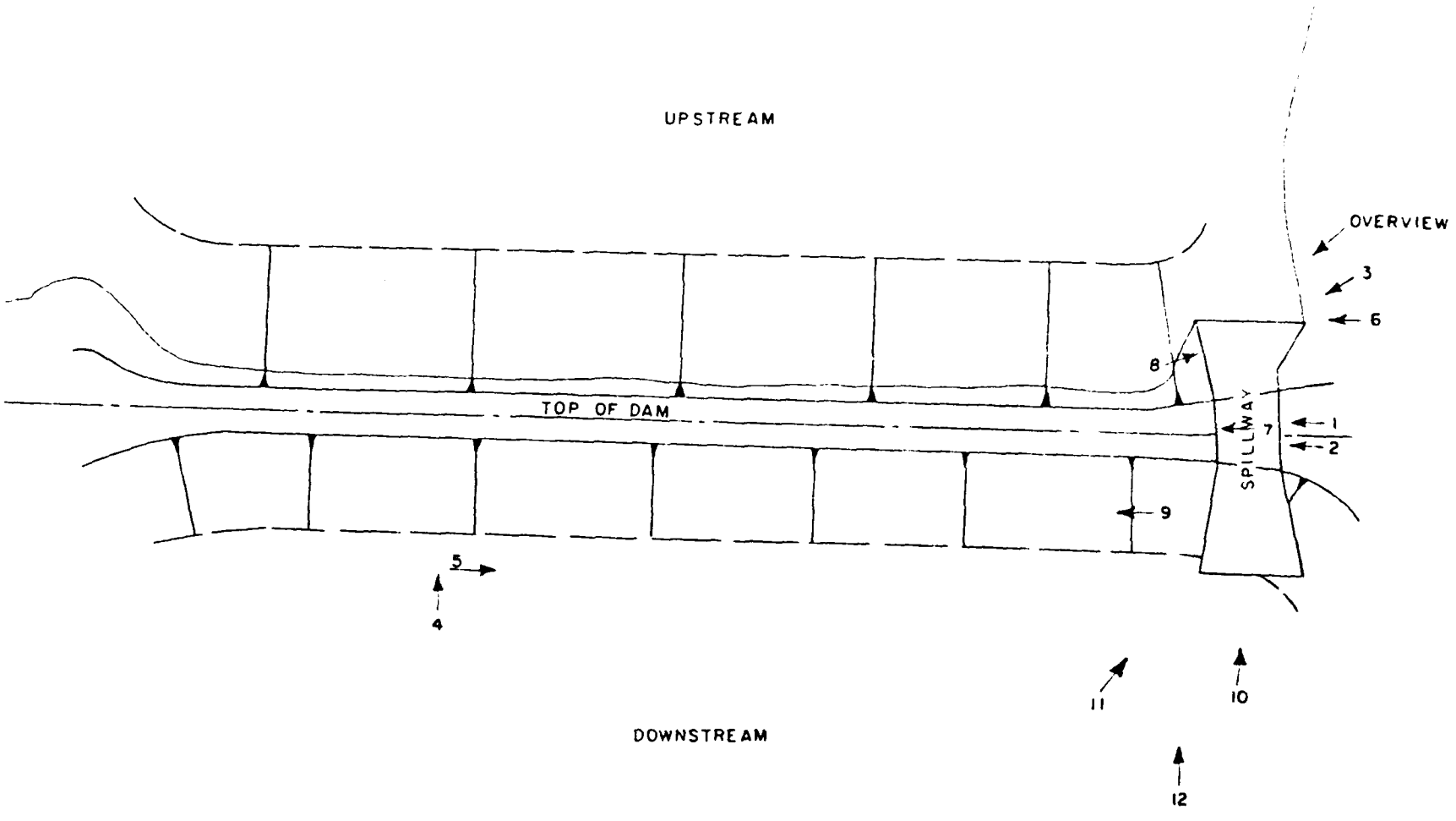
MISCELLANEOUS

Information located in DER files include

1. Application and permit for construction of the dam.
2. Correspondence and memorandums concerning the construction of the dam.
3. Thirteen black and white photographs.

APPENDIX

C

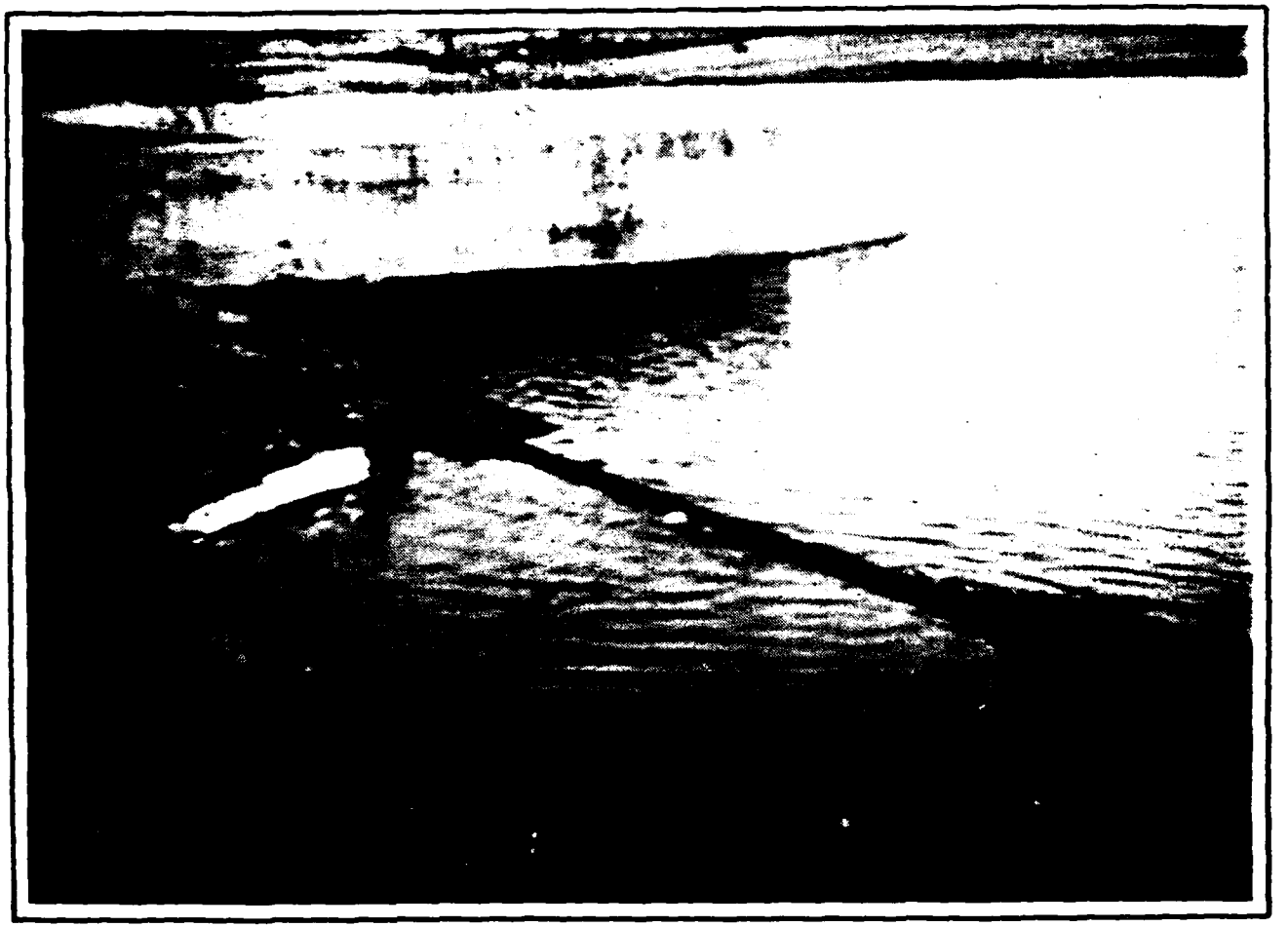


PHOTOGRAPH LOCATION PLAN
HILLOCH DAM

PLATE C-1

VIEW OF SPILLWAY TAKEN FROM LEFT ABUTMENT
AT EDGE OF SPILLWAY

PHOTOGRAPH NO. 1



1959 PHOTOGRAPH LOCATED IN STATE FILES SHOWING SPILLWAY

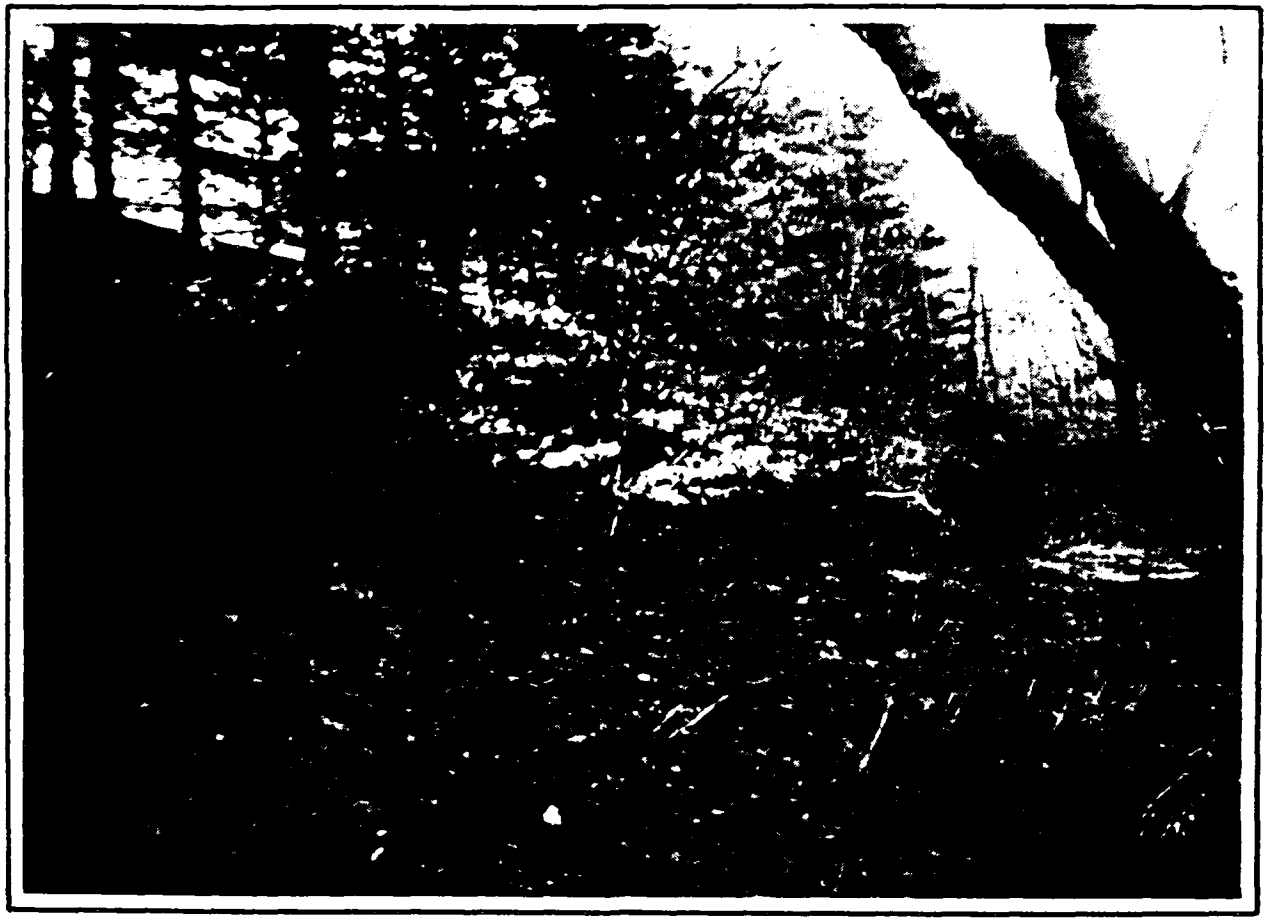
PHOTOGRAPH NO. 2

UPSTREAM SIDE OF SPILLWAY, LOCATED BETWEEN HOUSE AND CONCRETE WALL

PHOTOGRAPH NO. 3

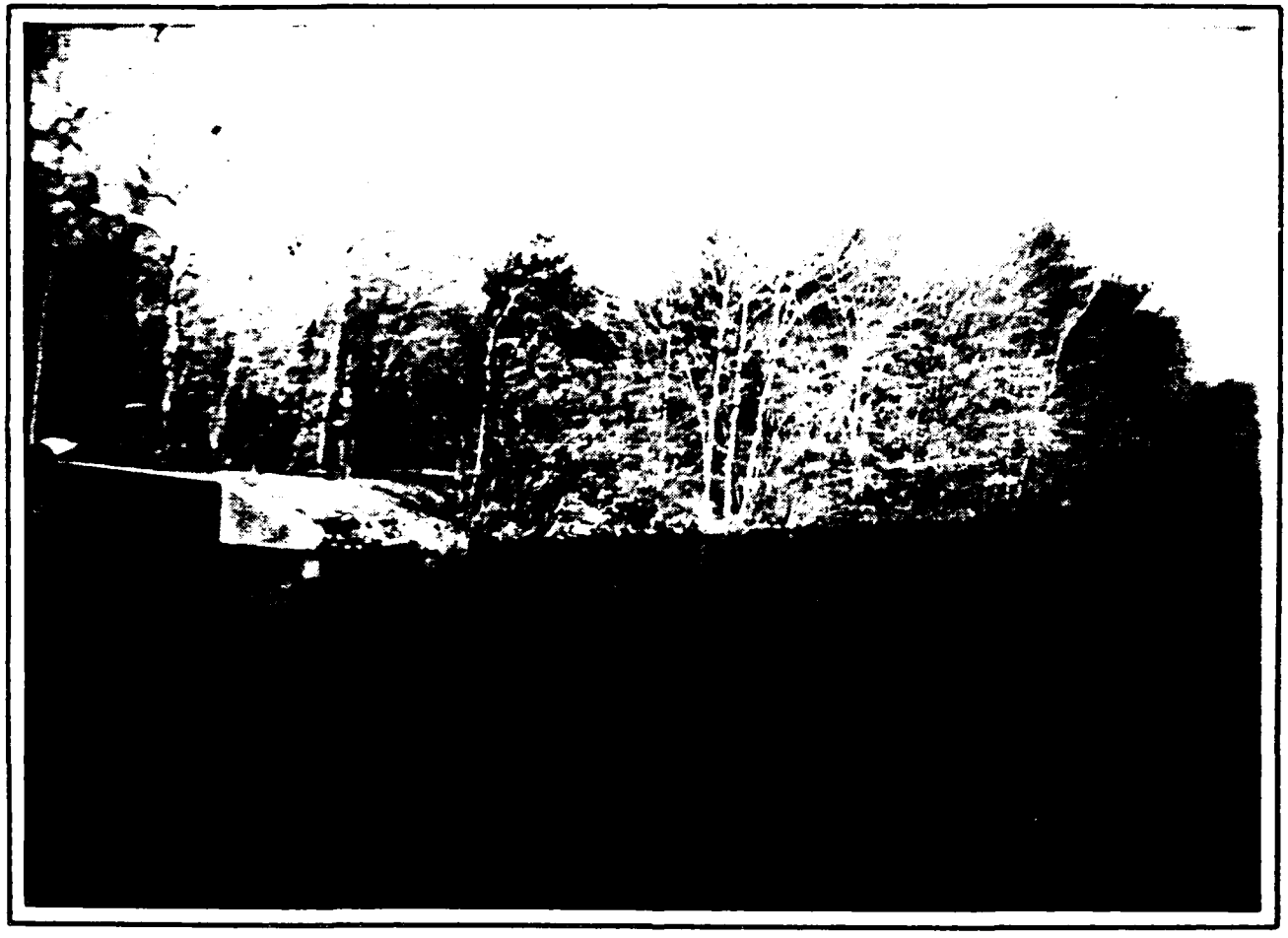
DOWNSTREAM END OF POND DRAIN

PHOTOGRAPH NO. 4



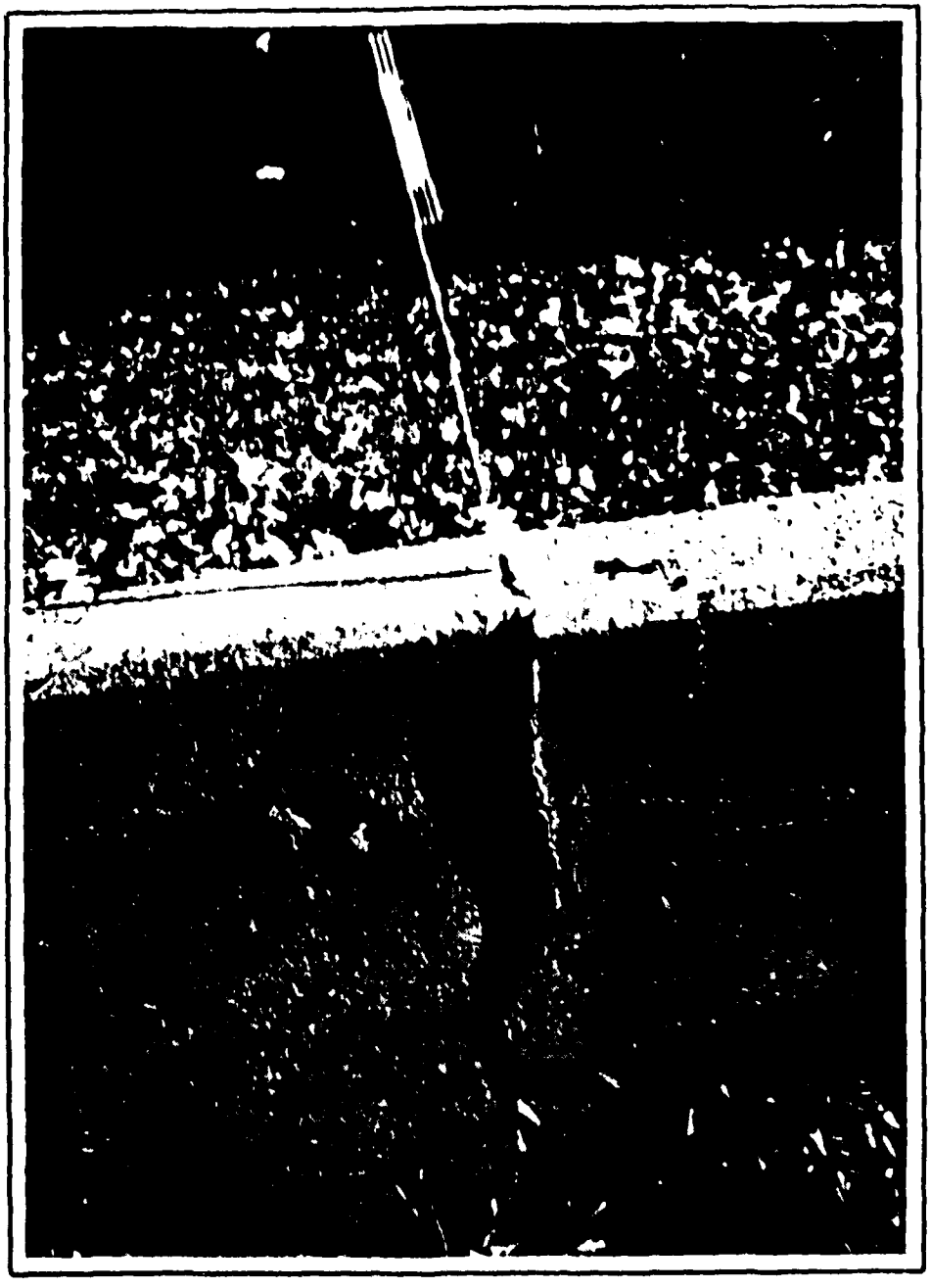
VIEW OF DOWNSTREAM EMBANKMENT SLOPE

PHOTOGRAPH NO. 5



VIEW SHOWING UPSTREAM EMBANKMENT SLOPE AND CREST

PHOTOGRAPH NO. 6



DAM CREST AND RIGHT SPILLWAY WALL
WITH 14 INCH DEEP CRACK
AND 1.5 INCH DISPLACEMENT BETWEEN WALL SECTIONS

PHOTOGRAPH NO. 7

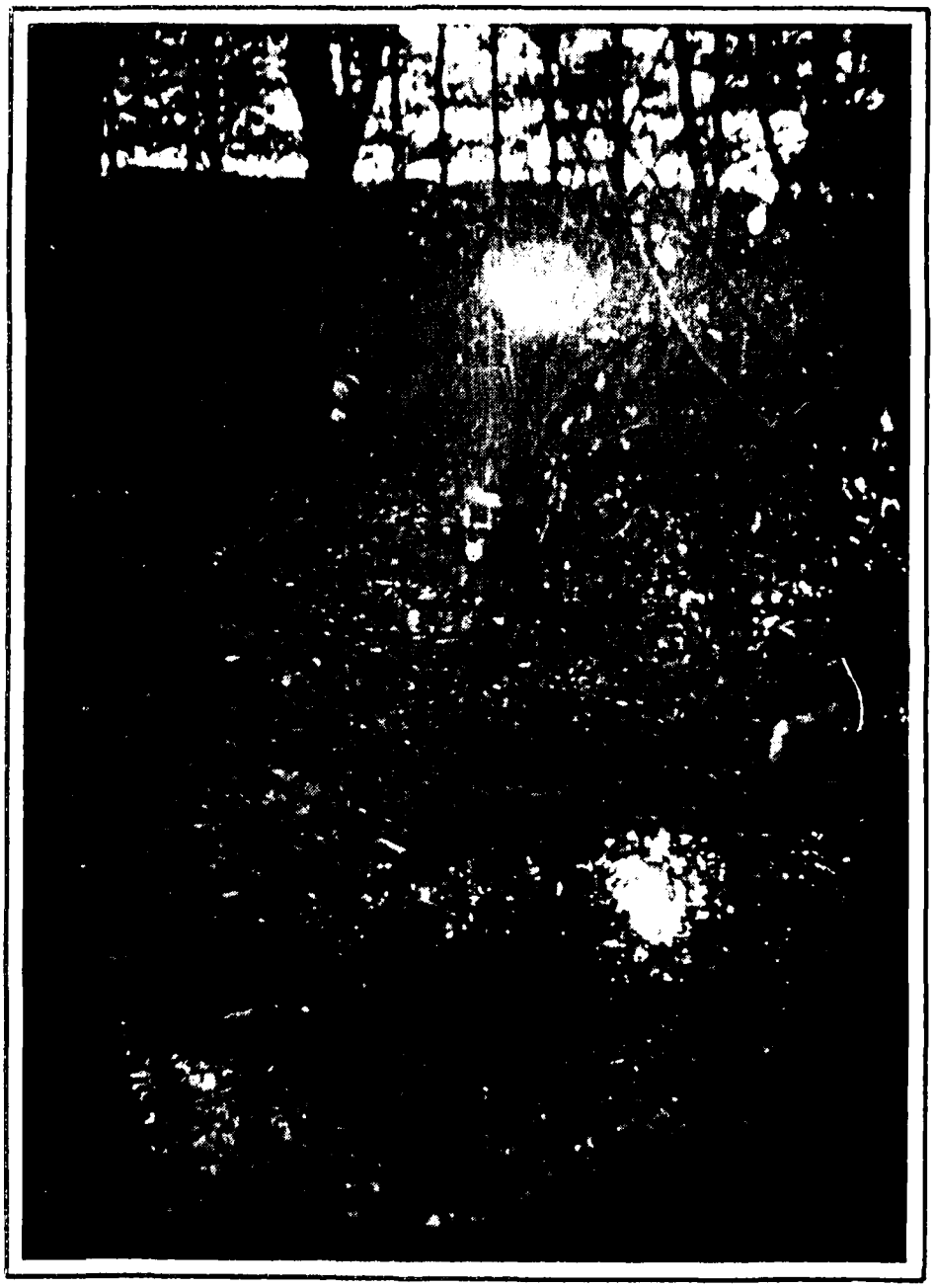
PHOTOGRAPH NO. 9

EROSION IN SPILLWAY CHANNEL. NORMAL SPILLWAY DISCHARGE CHANNEL IS TO THE RIGHT OF THE PICTURE.

PHOTOGRAPH NO. 10

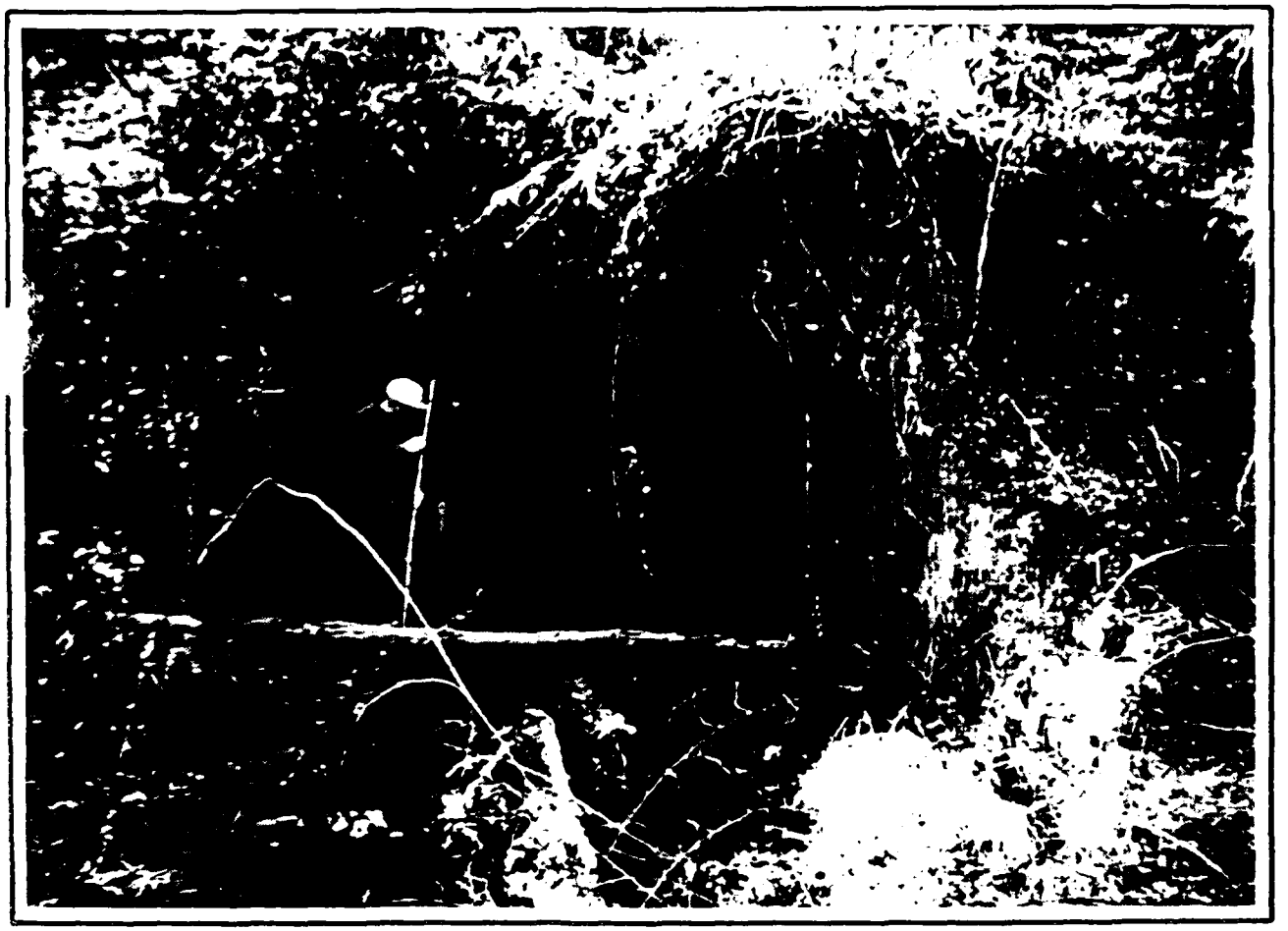
WATER UNDER LEAVES NEAR LEFT END OF EMBANKMENT

PHOTOGRAPH NO. 11



SEEPAGE PARTLY ATTRIBUTED TO SPILLWAY DISCHARGE
ENTERING ROCK AND EXITING FURTHER DOWNSTREAM

PHOTOGRAPH NO. 12

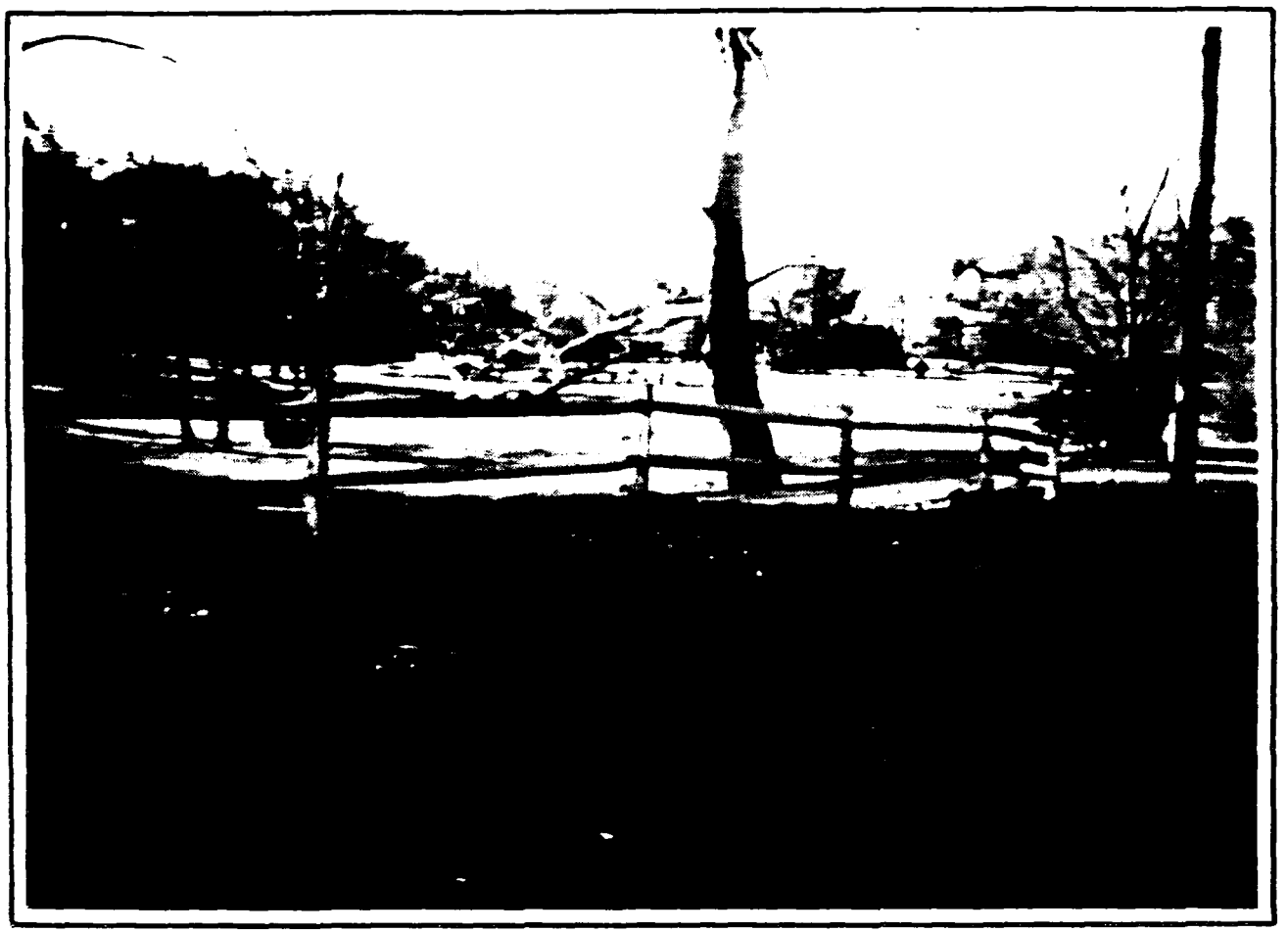


CULVERT THROUGH RAILROAD EMBANKMENT APPROXIMATELY 10 FEET WIDE AND 8.5 FEET HIGH - SEE PLATE 3, APPENDIX E.

PHOTOGRAPH NO. 13

HIGHWAY UNDERPASS THROUGH RAILROAD EMBANKMENT IS 22 FEET WIDE AND ABOUT 14.8 FEET ABOVE CULVERT INVERT SHOWN IN PHOTOGRAPH NO. 13

PHOTOGRAPH NO. 14



RAPID FAILURE OF DAM IS EXPECTED TO CAUSE WATER TO FLOW THROUGH HIGHWAY UNDERPASS CAUSING SIGNIFICANT DAMAGE TO HOUSE NEAR STREAM.

PHOTOGRAPH NO. 15

APPENDIX

D

HILLOCH DAM
CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: *About 25% wooded with predominently steep watershed slopes.*

ELEVATION NORMAL POOL (STORAGE CAPACITY): *227.8* feet (39 Acre - Feet)*

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): *229.9 feet (55 Acre - Feet)*

ELEVATION MAXIMUM DESIGN POOL: ——

ELEVATION TOP DAM: *229.9 feet*

SPILLWAY

a. Elevation *227.8 feet*

b. Type *paved channel*

c. Width *36 feet*

d. Length *about 50 feet*

e. Location Spillover *Left Abutment*

f. Number and Type of Gates *None*

OUTLET WORKS:

a. Type *5 inch C.I.P.*

b. Location *Approximately 65 feet from right abutment*

c. Entrance inverts *Unknown, under water*

d. Exit inverts *209.8 feet*

e. Emergency draindown facilities *the 5 inch C.I.P.*

HYDROMETEOROLOGICAL GAGES:

a. Type *None*

b. Location *N/A*

c. Records *N/A*

MAXIMUM NON-DAMAGING DISCHARGE: *Not Determined*

**Water surface elevation estimated as 228.0 feet from USGS map, all other elevations relative.*

HILLOCH DAM
CHECK LIST
HYDROLOGIC AND HYDRAULIC

DRAINAGE AREA:(1) *0.4 square miles*

100 YEAR PRECIPITATION (2)

30 MINUTES *2.5 inches*

1 Hour *3.2*

2 Hours *4.1*

3 Hours *4.4*

6 Hours *5.2*

12 Hours *6.2*

24 Hours *7.2*

SNYDER HYDROGRAPH PARAMETERS:(3)

Zone *10*

C_p, C_t *0.6, 1.25*

L (4) *0.99 miles*

L_{ca} (5) *0.43 miles*

$t_p = C_t (L \cdot L_{ca})^{0.3}$ *0.97*

SPILLWAY CAPACITY AT MAXIMUM WATER LEVEL (6) *611 cfs*

---

(1) Measured from USGS maps.
(2) TP 40 - Rainfall Frequency Atlas of the United States
(3) Information received from Corps of Engineers, Baltimore District.
(4) Length of longest water course from outlet to basin divide, measured from USGS maps.
(5) Length of water course from outlet to point opposite the centroid of drainage area, (see Plate 1, Appendix E) measured from USGS maps.
(6) See Sheet *12* of this Appendix.

HEC-1, REVISED
FLOOD HYDROGRAPH PACKAGE

The original "Flood Hydrograph Package" (HEC-1), developed by the Hydrologic Engineering Center, Corps of Engineers, has been modified for use under the National Dam Inspection Program. The "Flood Hydrograph Package (HEC-1), Dam Safety Version", hereinafter referred to as, HEC-1, Rev., has been modified to require less detailed input and to include a dam breach analysis. The required input is obtained from the field inspection of a dam, any available design/evaluation data, relatively simple hydraulic calculations, or information from the USGS Quandrangle maps. The input format is flexible in order to reflect any unique characteristics of an individual dam.

HEC-1, Rev. computes a reservoir inflow hydrograph based on individual watershed characteristics such as: area, percentage of impervious surface area, watershed shape, and hydrograph characteristics determined from regional correlation studies by the Corps of Engineers, Baltimore District. The inflow is routed through the reservoir using spillway discharge data obtained from the field inspection or design data. Flood storage capacity is determined from USGS maps or design information and verified by the field inspection. In the event a spillway cannot discharge 0.5 PMF without overtopping and failure of the dam, downstream channel characteristics obtained from the field inspection and USGS maps are inputed and flows are routed downstream to the damage center and a dam breach analysis is performed. If the 100 year event is selected as the appropriate spillway design flood, the peak inflow value is correlated with other studies by adjusting hydrograph parameters.

Included in this Appendix are the HEC-1, Rev. pertinent input values and a summary print-out tables.

BY MFB DATE 1/5/81 SUBJECT Hilloch Dam Hydrology/Hydraulics SHEET 4 OF 14

CHKD. BY DATE JOB No.

Classification (Ref. Recommended Guidelines for Safety Inspection of Dams)

1. The hazard classification is "Significant" as there would be appreciable economic loss with few lives lost in the event of a dam failure.

2. The size classification is "Small" based on its 20.1 foot height and 55 acre-foot total capacity.

3. The selected spillway design flood is the 100 yr event, based on size and hazard classification.

Hydrology and Hydraulic Analysis

1. Original Data.

Design spillway width 52 ft.
Maximum head 3.5 ft
Spillway type, paved channel through left abutment (assume broad crested weir with $C \sim 2.99$*)
Maximum discharge $Q = CLH^{3/2}$

$Q = 2.99 \cdot 52 \cdot 3.5^{3/2} = 1018$ cfs, more than the 1000 cfs requested by the state.

2. Evaluation Data.

Rainfall values and Snyder's hydrograph parameters are shown on sheet 2. The maximum discharge during a 100 year event is estimated according to procedures contained DER Water Resources Bulletin No. 13, Floods in Pennsylvania. The site is located in Flood-Frequency Region 7 (Plate I) The watershed is less than 15 sq miles, therefore,

$Q_{100} = 1110\, A^{0.825}$ where A = Watershed area in sq. miles

$= 1110\,(0.4)^{0.825}$

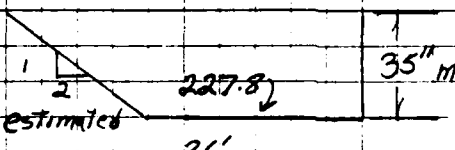
$= 521$ cfs

* Ref. Handbook of Hydraulics, King & Brater, 1976, Table 5-5

Elevation - Discharge Data - shown on sheets 10 & 13
Although a low sill is across spillway channel, estimate capacity by Mannings Equation

$$Q = a \frac{1.49}{n} \left(\frac{a}{w.p.}\right)^{2/3} s^{1/2}$$

where: a = cross-sectional area in sq. feet
n = roughness coefficient estimated as 0.055
W.P. = wetted perimeter
S = channel slope, 0.0338 from survey data



depth of flow (dn) ft	discharge cfs	critical depth (dc) ft	reservoir level neglecting entrance losses ft	
0	0	0	227.8	for a given
1	177	0.84	228.8	discharge, the
2	558	1.66	229.8	reservoir level is
3	1090	2.97	230.8	227.8 + the greater
4	1756	4.04	231.8	of dn or dc.
if spillway channel is restored to design conditions, n = 0.025				
1	390	1.53	229.3	
2	1224	3.20	231.0	
3	2398	4.92	232.7	

critical depth determined using ES-24 Soil Conservation Service National Engineering Handbook, Section 5

Elevation - Storage Data - shown on sheets 10 & 13
Areas were measured from U.S.G.S. map.
Normal Pool (227.8) = 7.35 Ac
230 ft. contour 8.57 Ac
240 ft. contour 12.2 Ac
Computer program computes volume

BY MEB DATE 1/20/81 3/13/81 SUBJECT Hillock Dam Hydrology/Hydraulics SHEET 6 OF 14

CHKD. BY ____ DATE ____ JOB No. ____

Spillway Adequacy

The spillway passes the 100 yr event without overtopping the low point of the embankment. However, the minimum freeboard should be one-foot, greater than the existing 0.3-foot freeboard, see sheet 12. The available freeboard increases to 0.4 feet if the spillway is restored to original condition. The purpose of the freeboard is to prevent damage to the crest by wind driven waves during the 100 yr event. Therefore, although the spillway is considered "Adequate", the embankment should be restored to 230.5 feet elevation to provide approximately one-foot of freeboard above the maximum pool for the 100 yr event.

If the embankment were restored to design elevation
230.7 (Text, Section 1.3)
− 229.5 high water w/ restored spillway (sheet 14)
1.2 freeboard

The maximum tailwater elevation during the 100 yr flood is estimated to be 208.9 from DS1, sheet 12.

1 PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	IN
ROUTE HYDROGRAPH TO	OUT
ROUTE HYDROGRAPH TO	DST
END OF NETWORK	

1**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80
****

RUN DATE= 81/01/12.
TIME= 14.27.54.

HILLOCH DAM
NDI NO. PA 00933 DER NO. 23-89
OVERTOPPING ANALYSIS

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
100	0	15	0	0	0	0	0	-4	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 1

RTIOS= 1.00

Sheet 7-6

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH - 100 YR STORM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
IN	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	1	.40	0.00	.40	1.00	0.000	0	1	0

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= .97 CP= .60 NTA= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 23 END-OF PERIOD ORDINATES, LAG= .98 HOURS, CP= .60 VOL= 1.00

18.	66.	122.	157.	152.	122.	93.	71.	54.	41.
32.	24.	18.	14.	11.	8.	6.	5.	4.	3.
2.	2.	1.							

END-OF-PERIOD FLOW

0

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	7.19	5.44	1.75	5648.
										(183.)	(138.)	(44.)	(159.93)

Sheet 8 of 14

ASSUMED RAINFALL DISTRIBUTION

```
0     96
01 .02  .02     .02     .02     .021    .021    .021    .021    .021    .021
01 .021 .021    .021    .021    .021    .021    .021    .021    .021    .021
01 .021 .021    .021    .021    .041    .041    .041    .041    .041    .041
01 .041 .041    .041    .041    .041    .041    .041    .041    .041    .041
01 .041 .041    .041    .041    .042    .042    .042    .042    .066    .066
01 .067 .067    .067    .067    .067    .068    .225    .225    .225    .225
01 .35  .35     1.25    1.25    .075    .075    .075    .075    .068    .067
01 .067 .067    .021    .021    .021    .021    .021    .021    .021    .021
01 .021  .021    .021    .021    .021    .021    .021    .021    .021    .021
01.021  .021    .02     .02     .02     .02
```

Sheet 9 of

HYDROGRAPH ROUTING

OUTFLOW HYDROGRAPH - EXISTING CONDITIONS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUT	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-228.	-1

STAGE	227.80	228.80	229.80	230.80	231.80
FLOW	0.00	177.00	558.00	1090.00	1756.00
SURFACE AREA=	0.	7.	9.	12.	
CAPACITY=	0.	39.	56.	160.	
ELEVATION=	212.	228.	230.	240.	

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
227.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
229.9	0.0	0.0	0.

CREST LENGTH AT OR BELOW ELEVATION	0. 229.9	150. 230.5	305. 231.2	318. 234.0

PEAK OUTFLOW IS 481. AT TIME 17.00 HOURS

HYDROGRAPH ROUTING

SECTION 100 FEET DOWNSTREAM OF DAM

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	DS1	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0550	.0550	.0550	208.0	218.0	100.	.03570

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 220.00 30.00 213.00 73.00 209.00 74.00 209.00 79.00 208.00
180.00 208.00 200.00 209.00 300.00 220.00

STORAGE	0.00	.13	.28	.44	.61	.80	1.00	1.21	1.43	1.67
	1.92	2.17	2.44	2.72	3.00	3.29	3.59	3.90	4.22	4.54
OUTFLOW	0.00	183.92	603.20	1246.98	2090.31	3130.52	4368.19	5805.62	7446.10	9293.52
	11369.73	13673.88	16187.31	18910.53	21844.56	24990.80	28350.92	31926.79	35720.49	39734.20
STAGE	208.00	208.53	209.05	209.58	210.11	210.63	211.16	211.68	212.21	212.74
	213.26	213.79	214.32	214.84	215.37	215.89	216.42	216.95	217.47	218.00
FLOW	0.00	183.92	603.20	1246.98	2090.31	3130.52	4368.19	5805.62	7446.10	9293.52
	11369.73	13673.88	16187.31	18910.53	21844.56	24990.80	28350.92	31926.79	35720.49	39734.20

MAXIMUM STAGE IS 208.9

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 1.00
HYDROGRAPH AT	IN	.40 (1.04)	1	516. (14.62)(
ROUTED TO	OUT	.40 (1.04)	1	481. (13.63)(
ROUTED TO	DS1	.40 (1.04)	1	481. (13.63)(

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	227.80	227.80	229.90
STORAGE	39.	39.	55.
OUTFLOW	0.	0.	611.

RATIO OF ~~PMF~~ 100-yr	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	229.60	0.00	53.	481.	0.00	17.00	0.00

PLAN 1 STATION DS1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	481.	208.9	17.00

Sheet 12 of 14

HYDROGRAPH ROUTING

OUTFLOW HYDROGRAPH - RESTORED CONDITIONS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUT	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-228.	-1

STAGE	227.80	229.30	231.00	232.70
FLOW	0.00	390.00	1224.00	2398.00
SURFACE AREA=	0.	7.	9.	12.
CAPACITY=	0.	39.	56.	160.
ELEVATION=	212.	228.	230.	240.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
227.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
229.9	0.0	0.0	0.

CREST LENGTH AT OR BELOW ELEVATION	0.	150.	305.	318.
	229.9	230.5	231.2	234.0

PEAK OUTFLOW IS 482. AT TIME 17.00 HOURS

SUMMARY OF DAM SAFETY ANALYSIS
(RESTORED CONDITIONS)

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	227.80	227.80	229.90
STORAGE	39.	39.	55.
OUTFLOW	0.	0.	684.

RATIO OF ~~PMF~~ 100yr	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	229.49	0.00	52.	482.	0.00	17.00	0.00

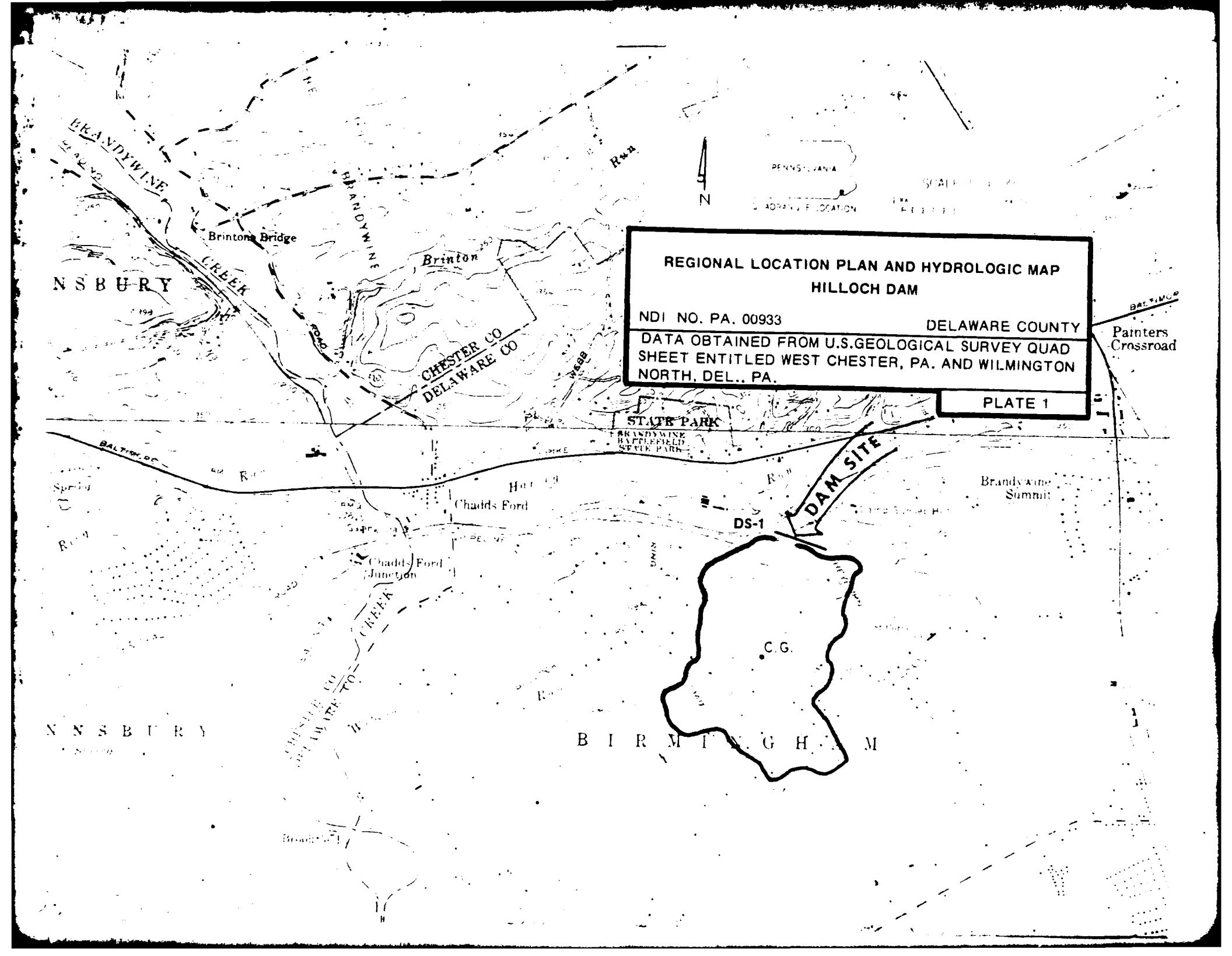
PLAN 1 STATION DS1

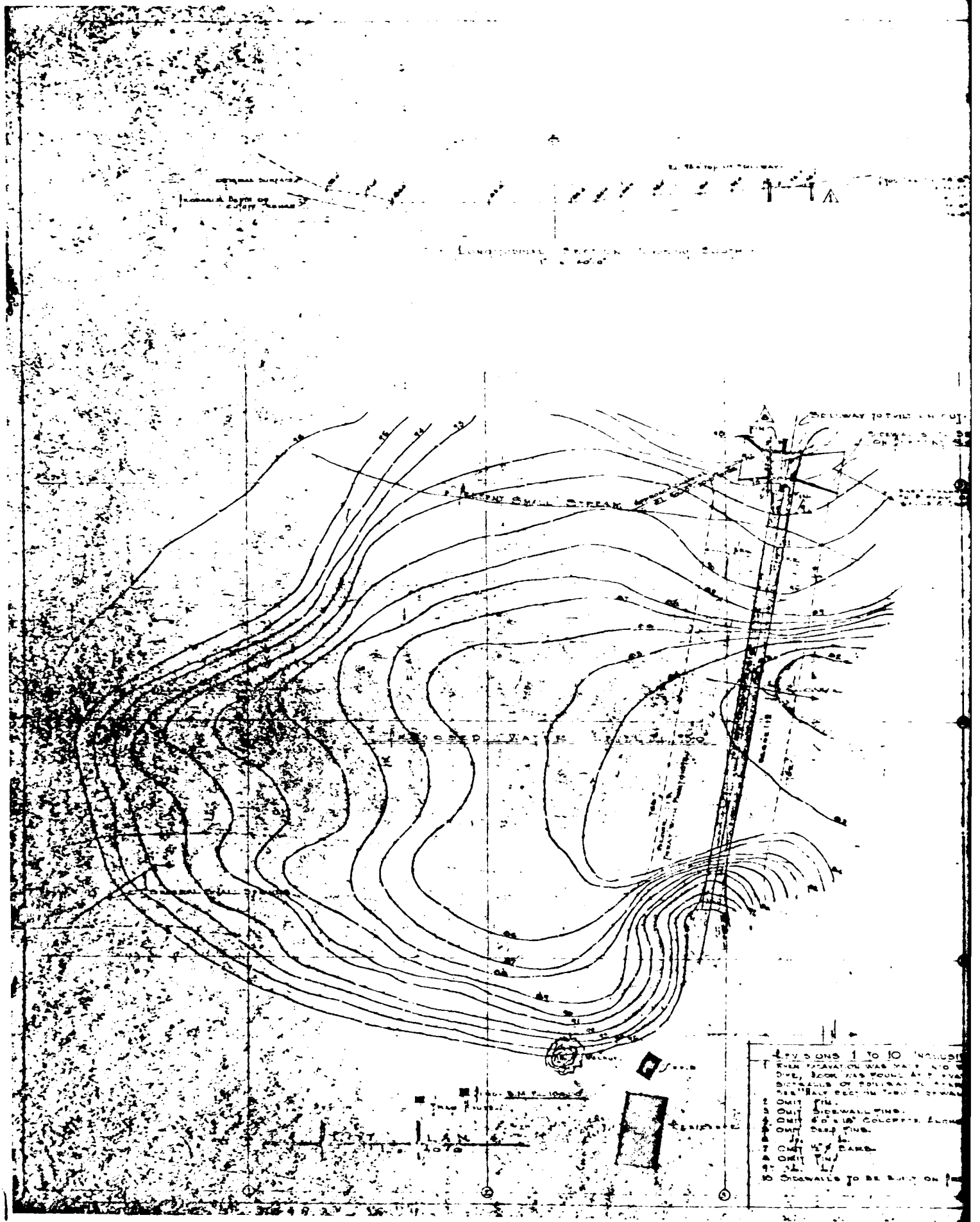
RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	483.	208.9	17.00

Sheet 14 of 1

APPENDIX

E


REGIONAL LOCATION PLAN AND HYDROLOGIC MAP
HILLOCH DAM
NDI NO. PA. 00933
DELAWARE COUNTY
DATA OBTAINED FROM U.S.GEOLOGICAL SURVEY QUAD SHEET ENTITLED WEST CHESTER, PA. AND WILMINGTON NORTH, DEL., PA.
PLATE 1
N
PENNSYLVANIA
Brintons Bridge
Brinton
BRANDYWINE CREEK
CHESTER CO
DELAWARE CO
STATE PARK
BRANDYWINE BATTLEFIELD STATE PARK
Chadds Ford
Chadds Ford Junction
Painters Crossroad
Brandywine Summit
DAM SITE
DS-1
C.G.
NSBURY
BIRMINGHAM



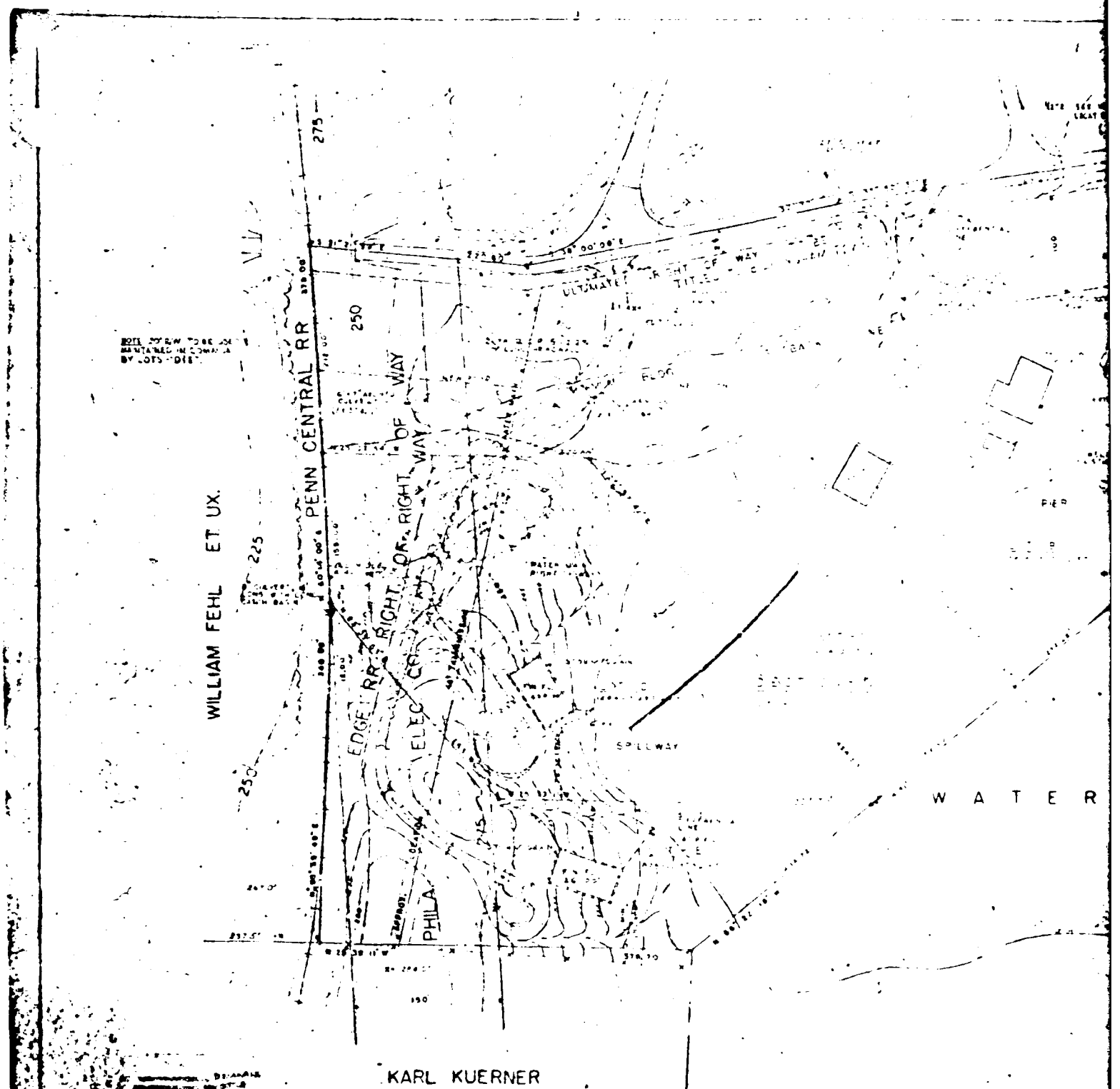
TYPICAL SECTION ON ℄

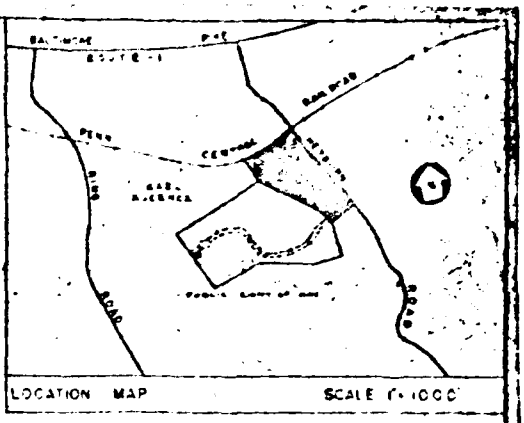
SPILLWAY BUILT ON CUT NO FILL

SECTION THRU SPILLWAY

JAMES P. PIERCE

PLAT


PENN CENTRAL RR
WILLIAM FEHL ET UX.
EDGE
RR
RIGHT OF WAY
ELEC
PHILA
SPILLWAY
WATER
KARL KUERNER



SAMUEL F LARKIN ET. UX.

W A T E R

Typical Lane Detail

Alternate-B New Residence

Total

FINAL SUBDIVISION SITE PLAN - SECTIONS "A&B"

PLATE 3

CHARLES MACHOLD WEYMOUTH
913 WASHINGTON STREET
WILMINGTON, DELAWARE

WEYMOUTH

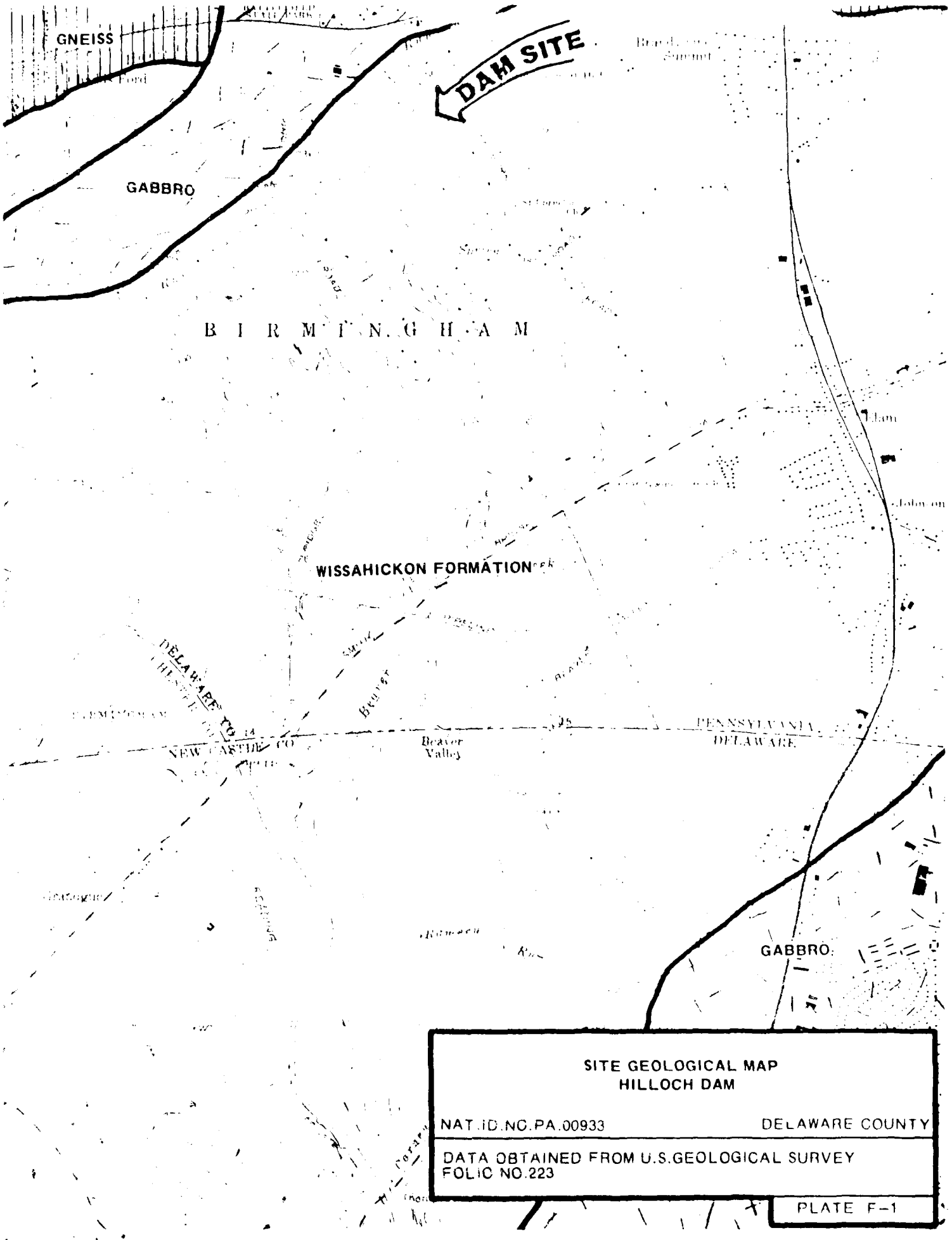
APPENDIX

F

HILLOCH DAM

SITE GEOLOGY

Hilloch Dam is located within the Piedmont Uplands section of the Piedmont physiographic province. As shown on Plate F-1, the bedrock in the dam vicinity is the Wissahickon Formation. Characteristically, this lower Paleozoic age formation consists predominantly of mica schist having gneissic portions locally. Information contained in the state files indicates that bedrock was encountered in the spillway portion of the dam, however, no bedrock exposures were observed at the spillway during the field inspection. Numerous boulders and rock fragments were observed in the stream channel downstream of the spillway possibly indicating shallow bedrock conditions. An exposure of gneissic bedrock occurs several hundred feet northeast of the spillway. Here foliation planes strike N 70° W and dip 25 degrees south. High angle jointing present strikes nearly east-west allowing for potential bedrock seepage.

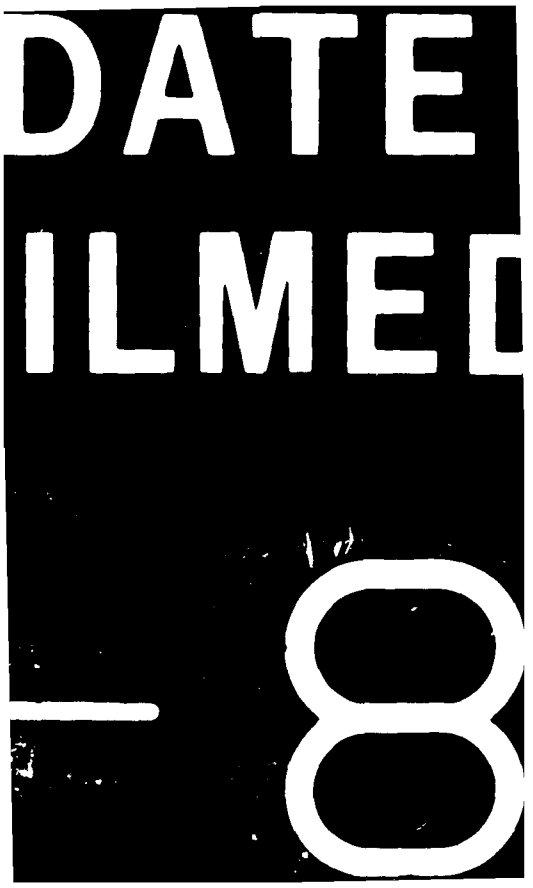


SITE GEOLOGICAL MAP
HILLOCH DAM

NAT.ID.NO.PA.00933 DELAWARE COUNTY

DATA OBTAINED FROM U.S.GEOLOGICAL SURVEY
FOLIO NO.223

PLATE F-1


DATE
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8